Mastering Unexpected Situations Safely
CarMaker @ Electronic Suspension Systems
IPG Apply & Innovate 2016/09/20
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Agenda

1. ESS: Organization and products
2. Model Implementation, Parameter Identification and Validation
3. CarMaker@ESS: Fields of Application
Electronic Suspension Systems within the Automotive Group

Automotive Group

Division Chassis & Safety

Division Interior

Division Powertrain

Vehicle Dynamics

Hydraulic Brake Systems

Advanced Driver Assistance Systems

Passive Safety & Sensorics

Electronic Brake Systems

Electronic Suspension Systems

Chassis Electronics

Continental
Business Unit Vehicle Dynamics (VED)
ESS is a Global Player! Customer overview
Electronic Suspension Systems
Product Portfolio

- Solenoid valve block
- Reservoir
- Compressor & Dryer
- Chassis Control Unit (incl. acc. Sensor)
- Strut with guided air spring, switchable volume, comfort bellow
- Free standing guided air spring and switchable volume
- 4 level sensors (for height control)
- 2-3 body acceleration sensors
- 500x39 Stefan Mølle, ESS (VED) © Continental AG
Electronic Suspension Systems
Air Suspension Benefits

**Dynamics & Comfort**
- Lowering vehicle’s CoG
- Lowered spring rate
- Reduction of Body Motion
- ~constant Eigenfrequency
- Reduction of unsprung mass

**Safety**
- Load independent ride height
- Full range of dynamic spring travel available
- Optimal tire traction
- Improved terrain ability (Variable ground clearance)
- Load detection

**ECO**
- Reduction of fuel consumption & CO₂ emissions
  (Aero Mode on highways)

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**Comfort**
**Dynamics**
**Safety**
**leveling**
**Emissions**
**Fuel**

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Air Suspension Benefits

Optimal Piston Contour
- Wide tuning range for optimal progression / degression

Switching spring volume: adapting base stiffness
- Realization of up to 4 natural air springs in one (multi-chamber design)
- Taking advantage of air damping effects
Electronic Suspension Systems
Requirements for ESS Simulation Environment

- Interface for Air Spring System Model
- One SW Environment for X-iL
- Full vehicle simulation, realtime and faster
- Possibility to enhance the simulation environment and .exe application
- Model Exchange with Customers, securing intell.-property
- Parameter studies, tests triggered by automated routine
- Good tool handling: realization of complex testruns, visual feedback
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Implementation via Simulink Interface

- **Co-Simulation** with Simulink or integration into CarMaker.exe via wrapper from CM
- In-house developed Matlab/Simulink component and (sub-)system Library used → high Modularity

- Used **Interface**: “External Suspension Forces”
## Electronic Suspension Systems
Identification & Data Acquisition for Validation

### VEHICLE
- Road test
  - e.g. Contidrom
  - 4-Poster test rig

### SYSTEM
- Kinematics rig
- Variable chassis frame

### COMPONENT
- Component test rig

### SUBCOMPONENT
- Subst. kinematics bench

### MODULE
- Module test rig

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+ Customer Data

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[Continental Logo]

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...Validation Using CarMaker

**VEHICLE**

Open loop road validation
Input: “Speed Profile Mode” and measured data as input file for open loop road validation

**SYSTEM**

Enhanced simulation environment:
- Modules for exciting wheel /4Poster)
- And chassis (kinematics test bench)

Input: Measured input signals (stroke)

**COMPONENT**

Stand-Still: levelling performance, load distribution

**SUBCOMPONENT**

On module level, only Matlab/Simulink serves as Simulation Platform

**MODULE**

Air Spring Model Matlab/ Simulink only

Open loop Maneuvers with Carmaker

Model of 4-poster test rig inside CarMaker

Model of kinematics test Bench inside CarMaker

Simplified 7 DoF stand-alone model
Electronic Suspension Systems
Simulation ready for Application

Base Set of Parameters
- Weight distribution; CoG
- matching Tire model (!)
- Base geometry (wheel base, width)
- Steering definition, Brake & PWT
- Air spring & buffer parameters
- Kinematics (camber/toe and leverage spring to wheel)
- Damper characteristics
- Parasitic & Stabilizer stiffness

For each level:
- Validity check of data set
- Loop identification if necessary
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Fields of Application: “Base studies”

- Switching logic
- Additional volumes switching strategy

RTI = Ramp Travel Index

- RTI = distance travelled on ramp / wheelbase x 1000 (Ramp angle 20°)
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Fields of Application: HiL

Chassis-Heights, Air spring + Reservoir pressure, air mass, Restbus (vehicle speed,...)

Air spring pressure

Level Ctrl. (LC)*

Actuator signals (Valve+Compr.)

Pneumatic Layout*
Valves, reservoir, tubes, …

Pre-/Counter-pressure

Compressor model*

Air mass flow

Air supply model

CarMaker vehicle simulation with Customer vehicle data set + tire model

Pressure (→ force)

displacement, forces

pneumatic air spring model*

Air spring+vehicle model (CM)

CarMaker® virtual test driving

Level Ctrl. (LC)*

Air mass flow

Air supply model

Compressor model*

Pneumatic Layout*
Valves, reservoir, tubes, …

Pre-/Counter-pressure

Actuator signals (Valve+Compr.)

Level Ctrl. (LC)*

Air spring pressure

Chassis-Heights, Air spring + Reservoir pressure, air mass, Restbus (vehicle speed,...)

*for customer: Provided as .mex or .fmu

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Public
Electronic Suspension Systems

Fields of **Application**: Function Test

- **Example**: testing a curve detection function

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**Simplified controller / Manipulator**

**Module from Application Software (ASW)**

- **Actuator signals**
- **Ext. Forces**
- **Autom. Testrun + Evaluation**

- **Height signals, accelerations, ...**

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**Example**: testing a curve detection function

- **Monitor**

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**CarMaker**, Test-Manager, Maneuver-catalogue & Python (planned)
Thank you for your attention!
Safe and Dynamic Driving
towards Vision Zero